Department of Energy
Washington, DC 20585

SAFETY EVALUATION REPORT (SER)
for the
Steel Banded Wooden Shipping Containers (SBWSC)
Docket Nos. 96-39-5467, 98-20-5467, and 98-22-5467
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SUMMARY

Based on the statements and representation in the Safety Analysis Report for Packaging (SARP), the staff has concluded that the design of the SBWSC meets the requirements of DOE Order 460.1A, 10 CFR Part 71, and 49 CFR Part 173.

REFERENCE

"Safety Analysis Report for Packaging, SBWSC, Docket No. 96-39-5467," HNF-SD-SARP-19, Revision G, 06/21/99, Fluor Daniel Hanford, Inc., Richland, WA.

CONTAINER MODELS AND TYPES

There are five different models of the SBWSC; they are identified as: Models G-4214, G-4245, G-4255, G-4273, and G-4292. There are two versions of Model G-4273 (4273-5 and 4273-6) depending on the height of the pallet cover lid.

There are two types of containers. Models G-4214, G-4245, and G-4292 are boxes with lids, and Models G-4255 and G-4273 are pallets with covers.

DRAWINGS

The SBWSC are defined by the following National Lead Company of Ohio, Inc. (NLO) and Westinghouse Materials Co. Of Ohio (WMO) drawings:

Model No.	Type[1]	Title	Drawing No.	Drawing Index Code	Rev No.
G-4214	Bw/L	Shipping Container	00F-5500-X-00431	06C-5500-X-07460	23
" "	" "	Aluminum Interior Liner for Shipping Containers Details	00F-5500-X-01490	" "	3
G-4245	Bw/L	SRP Samples Shipping Container	G-4245	00F-5500-X-00460	8
" "	" "	Plastic Cover for Wooden Containers	00F-5500-X-01753	" "	0
G-4255	Pw/C	"NPR" Billet Shipping Container Packaging Assembly Isometric	00F-5500-X-00468	" "	8
" "	" "	N.P.R. Billet Shipping Container Base Assembly Plan, Elevation, Sections & Details	G-4256	00F-5500-X-00469	2
" "	" "	N.P.R. Billet Shipping Container Base Assembly Plan & Elevations	G-4257	00F-5500-X-00470	0
G-4273	Pw/C	Ingot Shipping Container Packaging Assembly	00F-5500-X-00471	" "	18
" "	" "	Ingot Shipping Container Base Assembly, Assembly & Details	00F-5500-X-00472	" "	7
" "	" "	Ingot Shipping Container Cover Assembly	00F-5500-X-00473	" "	6
G-4292	Bw/L	Shipping Container No. 4	G-4292	00F-5500-X-00491	14

[1] Bw/L refers to the box with lid type, and Pw/C to the pallet with cover type.

CHAPTER 1 - GENERAL

The general information and drawings presented in the reference were reviewed by the staff and found acceptable. The SBWSC are adequately described by the above assembly and attendant drawings which provide specifications for the materials of construction, component dimensions, location, size, and type of joints on the packaging. Tamper-indicating seals may be installed on the containers or on the doors of the exclusive use transport trailers. In addition, the containers are sealed for transport with steel bands which must be removed prior to opening. These bands prevent unintentional opening and act as a tamper-indicating seal.

The SBWSC are Type AF packagings for shipping unirradiated uranium billets, ingots, derbies (slugs), and scrap metal enriched to a maximum of 1.25 ± 0.006 weight percent with ^{235}U. The SARP states that these packagings are Category III containers, but this designation applies only to packagings that contain Type B quantities of radioactive material. The A_2 value for uranium enriched to less than 20% is unlimited; therefore, the packaging contains a Type A quantity of radioactive material. Consequently, there are no specific ASME Boiler & Pressure Vessel Code requirements applicable to the design and fabrication of these packagings.

The total gross weights of the fully loaded containers are given in the Table below. The containers are shipped in exclusive-use trailers by highway, rail, or water.

Model No.	Type[1]	Container (Tare) Weight, kg (lb)	Maximum Payload Weight, kg (lb)	Maximum Package Gross Weight, kg (lb)
G-4214	Bw/L	27 (60)	544 (1,200)	572 (1,260)
G-4245	Bw/L	11 (25)	89 (197)	101 (222)
G-4255	Pw/C	54 (120)	610 (1,344)	664 (1,464)
G-4273-5	Pw/C	64 (140)	1,306 (2,880)	1,370 (3,020)
G-4273-6	Pw/C	65 (144)	1,582 (3,488)	1,647 (3,632)
G-4292	Bw/L	36 (80)	568 (1,252)	604 (1,332)

[1] Bw/L refers to the box with lid type, and Pw/C to the pallet with cover type.

This SER directly evaluates and assesses the integrity of the components that comprise the containers and evaluates the ability of these containers to provide protection to the enriched uranium billets, ingots, derbies (slugs), and scrap metal which comprise the contents during the normal conditions of transport (NCT) and hypothetical accident conditions (HAC) defined by DOE Order 460.1A and 10 CFR 71.

1.1 Description

1.1.1 Packaging

The containers (packagings) consist of enclosed wooden boxes reinforced and secured by steel bands. There are five models and two types, or classes, of boxes. The classes consist of a box with a lid, and a pallet with a cover. All of the boxes have hardwood skids to facilitate handling with a fork lift. The boxes are made from wood boards, exterior grade plywood, steel nails, steel bolts and nuts, and aluminum bars (Type 2024-T351 or 6061-T651). All of the boxes are secured with steel bands for transport. The bands are made from 3.18 cm (1.25 in) wide steel band material that meets the requirements of ASTM D-3953-91 (Standard Specification for Strapping, Flat Steel and Seals) and has a minimum tensile strength of 30,025 N (6750 lb). The boxes are banded horizontally and vertically, and each band is secured with at least one seal that is closed with two pairs of notches in accordance with the recommendations given in Fig. 1 of ASTM D-3953-91. The steel bands are installed using the manufacturers guidelines and the guidelines in ASTM D-4675-93 (Standard Guide for Selection and Use of Flat Strapping Materials). The external dimensions of the containers are given in the following Table.

Model No.	Type[1]	Width, cm (in.)	Length, cm (in.)	Height, cm (in.)	Height with Skid, cm (in.)
G-4214	Bw/L	41.59 (16-3/8)	87.63 (34-1/2)	26.04 (10-1/4)	36.20 (16-3/8)
G-4245	Bw/L	31.12 (12-1/4)	46.99 (18-1/2)	25.40 (10)	33.34 (13-1/8)
G-4255	Pw/C	65.09 (25-5/8)	88.90 (35)	24.77 (9-3/4)	33.02 (13)
G-4273-5	Pw/C	68.58 (27)	104.78 (41-1/4)	34.93 (13-3/4)	43.18 (17)
G-4273-6	Pw/C	68.58 (27)	104.78 (41-1/4)	40.00 (15-3/4)	48.26 (19)
G-4292	Bw/L	41.59 (16-3/8)	87.63 (34-1/2)	46.04 (18-1/8)	55.25 (21-3/4)

[1] Bw/L refers to the box with lid type, and Pw/C to the pallet with cover type.

1.1.1.1 Model G-4214

This container is a box with a lid and has 2.86 cm (1-1/8 in.) thick sides and ends made from white pine, a 2.86 cm (1-1/8 in.) thick bottom made from hard maple, and a 1.27 cm (1/2 in.) or 2.54 cm (1 in.) thick lid made from interior-grade plywood with exterior-grade glue. Each of the three skids are made from three layers of white pine nailed and glued together with Weldwood plastic resin adhesive. The skid gap is 10.16 cm (4 in.). When a side or bottom consists of more than one piece of wood, the joint is tongue and groove. The sides, ends, and bottom are fastened together with spiral-threaded nails.

The Model G-4214 box can also be used with a protective liner made from 0.08 cm (0.032 in.) thick Type 6061-T6 aluminum. This liner covers all interior surfaces of the box to prevent the possibility of corrosion damage to the contents.

The Model G-4214 box has internal dimensions of 35.88 cm (14–1/8 in.) wide, 76.20 cm (30 in.) long, and 21.27 cm (8–3/8 in.) high.

1.1.1.2 Model G-4245

This container is a box with a lid and has 2.86 cm (1-1/8 in.) thick sides and ends made from white pine, a 2.54 cm (1 in.) thick bottom made from oak, and a

1.27 cm (1/2 in.) thick lid made from exterior-grade plywood. Each of the two skids are made from two layers of wood nailed together. The skid gap is 7.94 cm (3–1/8 in.). When a side or bottom consists of more than one piece of wood, the joint is tongue and groove. The sides, ends, bottom, and skids are fastened together with spiral-threaded nails.

The Model G-4245 box is used with a protective cover made from T-55 Griffolyn nylon reinforced, clear plastic.

The Model G-4245 box has internal dimensions of 25.40 cm (10 in.) wide, 35.56 cm (14 in.) long, and 21.59 cm (8-1/2 in.) high.

1.1.1.3 Model G-4255

This container is a pallet with a cover. The pallet base is made from 1.91 cm (3/4 in.) and 2.54 cm (1 in.) exterior grade plywood laminated together with 0.64 cm (1/4 in.) diameter steel lag screws. Blocks to fix the location of the cover and to chock the contents are made from oak and are fastened to the pallet base with the lag screws and No. 8 flat head wood screws. The three skids are made from native hardwood and laminated together and fastened to the pallet base using 0.79 cm (5/16 in.) diameter steel bolts and nuts with flat and lock washers. The skid gap is 8.26 cm (3-1/4 in.).

The cover is made from exterior plywood and reinforced with 5.08 x 2.86 cm (2 x 1-1/8 in.) nailing strips made from white pine. The plywood for the top and sides is 1.91 cm (3/4 in.) thick, and the ends are 2.54 cm (1 in.) thick. Spiral-threaded nails are used to fasten the cover pieces together.

When transporting NPR billets, spacers consisting of 0.64 cm (1/4 in.) thick exterior plywood are placed between the billets and banded together with the billets to the pallet base before the cover is installed.

The Model G-4255 box has internal dimensions of 61.28 cm (24–1/8 in.) wide, 78.11 cm (30–3/4 in.) long, and 20.32 cm (8 in.) high.

1.1.1.4 Model G-4273

This container is a pallet with a cover. The pallet base is made from 1.91 cm (3/4 in.) and 2.54 cm (1 in.) exterior grade plywood laminated together with 0.64 cm (1/4 in.) diameter steel lag screws. Blocks to fix the location of the cover and to chock the contents are made from oak and Type 2024-T351 or 6061-T651 aluminum bar stock and are fastened to the pallet base with the lag screws and 0.64 cm (1/4 in.) diameter steel bolts and nuts with flat and lock washers. The three skids are made from native hardwood and laminated together and fastened to the pallet base using 0.79 cm (5/16 in.) diameter steel bolts and nuts with flat and lock washers. The skid gap is 8.26 cm (3-1/4 in.). For transport, spacers consisting of 0.64 cm (1/4 in.) thick exterior plywood are placed between the ingots and banded together with the ingots to the pallet base before the cover is installed.

The cover is made from exterior plywood and reinforced with 5.08 x 2.86 cm (2 x 1-1/8 in.) nailing strips made from white pine. The plywood for the top and sides is 1.91 cm (3/4 in.) thick, and the ends are 2.54 cm (1 in.) thick. Spiral-threaded nails are used to fasten the cover pieces together.

There are two different size covers for this packaging. For ingots with 27.94 cm (11 in.) diameter or less, the standard 32.39 cm (12–3/4 in.) high cover is used (Model G-4273-5). For ingots 33.02 cm (13 in.) diameter, a cover that is 37.47 cm (14-3/4 in.) high is used (Model G-4273-6).

The Model G-4273-5 box has internal dimensions of 64.77 cm (25–1/2 in.) wide, 93.98 cm (37 inches) long, and 30.48 cm (12 in.) high. The Model G-4273-6 box has internal dimensions of 64.77 cm (25-1/2 in.) wide, 93.98 cm (37 in.) long, and 35.56 cm (14 in.) high.

1.1.1.5 Model G-4292

This container is a box with a lid and has 2.86 cm (1-1/8 in.) thick sides and ends made from white pine, a 2.54 cm (1 in.) thick bottom made from maple, and a 2.54 cm (1 in.) thick lid made from exterior-grade plywood. Each of the two skids are made from three layers of 5.08 x 10.16 cm (2 x 4 in.) wood nailed together. The skid gap is 9.21 cm (3-5/8 in.). When a side or bottom consists of more than one piece of wood, the joint is tongue and groove. The sides, ends, bottom, and skids are fastened together with spiral-threaded nails.

The Model G-4292 box has internal dimensions of 35.88 cm (14–1/8 in.) wide, 76.30 cm (16-1/8 in.) long, and 40.96 cm (16–1/8 in.) high.

Containment Boundary The containment boundary of the SBWSC consists of the wooden structure of the container. The contents of these packagings do not have or generate any internal pressure, and do not generate any significant decay heat. The details of the external banding for each model for transport are shown in Figures 1.2.1-1 through 1.2.1-5 in the SARP.

1.1.2 Operational Features

The SBWSC are lifted by a fork-lift using the space between the skids for the lifting forks. There are no tie-down devices attached to the packaging, it is secured during transport within the trailers by steel straps similar to those used to band the packagings. The packagings have nameplates attached to the containers. The nameplate complies with the regulatory requirements in 10 CFR 71.85 and 49 CFR 173.444.

1.2 Contents

The SBWSC are designed to transport residual uranium metal products from the N reactor program. These are unirradiated uranium billets, ingots, derbies (slugs), and scrap metal enriched to a maximum of 1.25 ± 0.006 weight percent with ^{235}U.

The contents consist of N Reactor ingots and Mark 15 ingots (shipped in box Model G-4273), RMI forged billets (shipped in box Models G-4255, G-4214, or G-4292), FERMCO derbies (slugs) (shipped in box Models G-4214 or G-4292), FERMCO ingots and ingot sections (shipped in box Models G-4273, G-4214, G-4292, or G-4245), and cylindrical scrap form FERMCO ingots and ingot sections (shipped in box Models G-4292 or G-4214).

The physical dimensions and weights of these products are listed in Table 1.2.3-1 of the SARP. The recommended packaging and maximum number of packages per shipment of these products is listed in Table 1.2.3-2 of the SARP. These recommendations are based on criticality or shielding evaluations conducted by the applicant.

The maximum amount of ^{235}U to be shipped <u>per box</u> is 16.81 kg (two N reactor ingots in Box G-4273-6), and the maximum ^{235}U <u>per shipment</u> is 218.47 kg (481.65 lb) (two Mark I Outer N Reactor Ingots per Model G-4273-6 box, or two 33.15 cm (13.05 in) diameter FERMCO Product Ingots per Model G-4273-6 box). The maximum weight of contents to be transported per shipment is 18,775 kg (41,392 lb) (gross weight of 19,624 kg [43,264 lb) of unirradiated uranium metal. This maximum weight shipment consists of two Mark IV Inner N Reactor Ingots per Model G-4273-6 box with 13 boxes per shipment.

The payloads requested in Revision G of the SARP that are not covered in this SER include Mark 15 Outer Ingots, FERMCO Product Ingots, FERMCO Ingot Sections, and FERMCO Scrap listed in Table 1.2.3-2 of the Rev. G SARP.

CHAPTER 2 - STRUCTURAL

2.1 Structural Design

2.1.1 Discussion

The designs of the SBWSC were first certified in July of 1974. Five container geometries, as described in the Rev. G of the SARP, are considered. The SARP documents compliance of these designs with 10 CFR Part 71 NCT requirements through physical tests that were performed for each type of box. Compliance with the 10 CFR Part 71 HAC requirements is demonstrated by showing that the unconfined and unshielded contents alone meet all applicable HAC requirements without any recourse to packaging considerations.

The independent confirmatory investigations performed by the EM-70 staff, and summarized in this report, consisted of a critical review and evaluation of the material presented in Chapter 2 of the SARP submitted by the applicant, review of information contained in the supporting documentation referenced in the SARP, and independent assessments carried out to confirm the critical features of the designs. The primary structural components of these packagings are the pine, hardwood, and plywood components of the boxes and the steel banding strapped around these components.

2.1.2 Design Criteria

The Design Criteria section of the SARP specifies that the function of the package is to confine the contents under the NCT. Under HAC the regulations do not impose a release limit for containment purposes since this packaging is Type AF and therefore the total inventory of radioactive material is less than one A_2. The criticality and shielding requirements are met by the contents alone without any recourse to packaging considerations; therefore, no structural HAC design criteria are needed. The packaging design criteria have been reviewed by the staff, and were found to be acceptable. The design criteria used in the confirmatory evaluation were consistent with those described above.

2.2 Weights and Centers of Gravity

The SARP lists the weight of the package with contents, ranging from 222 lb to 3632 lb depending an the specific package and contents. Table 2.2-1 in the SARP provides the specific tare weight and maximum gross weight for each packaging type. The tare weights range from 25 lb to 144 lb. The location of the center of gravity is given in the SARP as the geometric center of each container. Staff confirmatory review noted this information and found these weights to be reasonable for the materials and box dimensions provided in the SARP.

2.3 Mechanical Properties of Materials

The materials that affect the structural behavior of the SBWSC are identified in the SARP. Conventional lumber components are used throughout. The steel banding used is per ASTM specification D-3953-91. The wood materials selection and the steel banding specifications have been reviewed by the staff and have been found to be consistent with the needs of this packaging. The SBWSC provide containment for the slightly enriched solid uranium metal contents. Staff confirmatory review has found the materials data presented in the SARP to be adequate for the expected service and use of this packaging.

2.4 General Standards

The SARP addresses the 10 CFR 71.43 general requirements, such as minimum size and inadvertent opening. These requirements are met as follows. The smallest overall dimension is about 13 inches which is larger than the 4-inch minimum specified in 10 CFR 71.43(a). Tamper indication is achieved by the standard numbered seals placed on the exclusive-use trailer doors prior to shipment. Positive closure for the SBWSC is provided by means of the steel bands. There are at least two bands in each of two orthogonal directions around the boxes. The steel bands must be removed to open the packaging. This prevents unintentional opening, as required by 10 CFR 71.43(c). Finally, the materials used in the SBWSC are compatible with each other, and no chemical or galvanic reactions would be expected between any of the materials which are in contact in this packaging.

2.5 Lifting and Tiedown Devices

The SBWSC are designed to be lifted by a fork lift. The bottom skids which are solid hardwood timbers with a 3 to 4 inch square cross sections facilitate the lifting with a fork lift. Therefore, there are no lifting devices that would require 10 CFR 71.45(a) consideration.

The boxes have no tie-down devices. During transport the boxes will be tied down in the exclusive use transport using strapping similar to that used as bands around the boxes. This is described in the SARP in item 9 of Section 7.1.2. There are no structural parts that could be used for unintended tie-down. The boxes have a "clean" design with no protrusions that could be misused as tie-down fixtures. Hence, there are no components that the requirements of 10 CFR 71.45(b) would apply to.

2.6 Normal Conditions of Transport (NCT)

2.6.1 through 2.6.4 Temperature and Pressure

The SBWSC SARP addresses the ambient environmental conditions associated with the NCT stipulated in 10 CFR 71.71 including hot, cold, overpressure, and under-pressure, and finds that the boxes remain in compliance with the applicable requirements stipulated in 10 CFR 71.43. Specifically, the behavior of the conventional hardwood/plywood/pine nailed and banded box construction is not sensitive to the hot and cold temperature conditions of 10 CFR 71.71(c)(1) and (2). The boxes use no gaskets or other materials that may be temperature-sensitive to the normal conditions ambient temperatures. No containments that could develop pressures are involved. Internal heat generation is much less than a watt which is not significant. Similarly, for the ambient pressure conditions, it is recognized that the packaging provides no pressure retention and therefore the environmental pressure conditions specified in 10 CFR 71.71(c)(3) and (4) do not affect this packaging.

2.6.5 Vibration

The SARP addresses vibration loadings by explaining that these wooden packages are not affected adversely by vibration effects. The staff observed that the packaging uses standard trucking industry steel banding hardware that results in positive closures highly resistant to vibration effects. The heavy stock lumber and plywood components used readily damp out vibrations. It was also noted that the SBWSC have experienced extensive usage without encountering any vibration induced problems. The staff therefore concludes that the SBWSC will perform as required under the 10 CFR 71.71(c)(5) vibration conditions.

2.6.6 Water Spray

The SARP addresses the 10 CFR 71.71(c)(6) water spray conditions by reference to physical tests that were conducted for each of the box types under consideration here. The test results are provided in a "Final Evaluation Report" signed off on 9-19-90 and 9-21-90, which was provided with Rev. D of the SARP. The water spray environment did not affect the subsequent performance of these boxes. The staff reviewed this information and concluded that wooden boxes of the type of construction described in this SARP would not be expected to experience adverse effects from the water spray tests. The criticality analyses which are sensitive to water, discussed in detail in Chapter 6 - Criticality of Rev. F of the SARP, assume the worst case water environment (optimal hydrogenous moderation) and do not rely on any water resisting aspects of the packaging. The staff therefore concludes that the SBWSC will perform as required under the 10 CFR 71.71(c)(6) water spray conditions.

2.6.7 Free Drop

For the SBWSC, 10 CFR 71.71(c)(7) requires a Normal Condition of Transport free drop test from a drop height of four feet. The SARP addresses the effects of this drop by presenting the testing performed in the DOT 7A Type A Packaging certification program. The test results are provided in the "Final Evaluation Report" cited above. This report was provided with the SARP. In this test series each of the five packaging designs was tested by dropping a representative box loaded with its proposed contents. A total of 16 drop tests is reported. Two to four drop orientations were selected for each design. Most of the drops used a center of gravity over the corner oblique orientation which should be the most severe orientation for this packaging. In addition, two drops to the flat side of the packaging were performed. All the drops were from the height of four feet. Some damage to the boxes results from each of the drops, but in all cases the boxes retained their geometric configuration. Of the 16 drops, only two resulted in significant opening along an edge of a box. The opening was approximately two inches wide and appeared only in the largest boxes with the heaviest payload. In this case, the payload, which was essentially a solid cylindrical item 10 or more inches in diameter and 17 or more inches long, was strapped to the bottom of the box by internal strapping. Although damage to the box structure had occurred, the payload remained securely strapped to the skid portion of the box. Therefore, in actual transport the payload would remain securely strapped to the skid which in turn would remain securely strapped inside the exclusive-use trailer.

The applicable acceptance criteria for damage to fissile material packaging following a Normal Condition of Transport drop are those of 10 CFR 71.55(d), namely that:

1. the contents remain subcritical,

2. the geometric form of the contents is not substantially altered,

3. inleakage of water beyond that used in the criticality evaluation is prevented, and

4. no substantial reduction in the effectiveness of the packaging results.

Each of these 10 CFR 71.55(d) criteria refers to criticality control. Criteria (1) and (3) are automatically satisfied for this packaging because the criticality evaluation assumes no controls to demonstrate that the contents will remain subcritical under all postulated circumstances. Criterion (2) was demonstrated by the 16 drop tests referred to above since none of the payload items deformed in any of these tests. Criterion (4) has further sub-criteria related to criticality computation spacing which is not a concern in this packaging and a provision that the resulting damage not admit a "4-inch cube" into the packaging. The latter is satisfied since the largest opening resulting from the drop test was limited to about two inches and also because the exclusive-use security doors would have to be opened before any access to the packaging were possible, thus preventing the introduction of a "4-inch cube" of some other fissile material to the vicinity of the packaging. Thus, the 10 CFR 71.55(d) criteria appear to be met.

Independent confirmatory review consisted of a thorough evaluation of the test data presented. It was recognized that the behavior of SBWSC under the four foot oblique drop loadings could not be evaluated effectively by analytical means due to the complexity of the interaction of the wood components with the steel banding. Reference to actual test results was considered to be much more meaningful than any attempted analysis. With a total of 16 tests in various orientations and on various geometrical configurations of boxes, the results were considered to be statistically significant. As is always the case in an evaluation by testing, damage somewhat beyond the damage envelope observed in the tests is possible, but is not a concern because the tests demonstrate that the packaging satisfies the specific requirements related to the 10 CFR 71.71 tests. It is also noted that an incremental damage beyond that actually observed would not constitute an increased safety concern. The concern that more testing might possibly show more severe damage was also addressed by reviewing the strapping techniques used for this packaging. The steel strapping, and its method of application, is an important determinant of the structural behavior of these packagings. It was verified that the strapping operation is performed to a recognized standard and that the standard is called out in the packaging drawings and operating procedures. It was also verified that the test articles were fabricated to the same standard.

Even though reference to actual test results was considered to be more meaningful than an analysis, staff independent confirmatory review did include an analytical review of the four foot oblique drop with center of gravity over the edge of a SBWSC. Specifically, the most severe case was considered, that being the heaviest loading for the G-4273-6 box, dropped on the upper short direction edge. This orientation is most severe because the payload is strapped to the skid and transmits its load to the point of impact through the in-plane shear loading of the side plywood panels. Assuming a uniform deceleration during impact using an external crushing distance of about two inches as observed in the tests, plus the same distance internally due to deformation of the wooden members supporting the payload, shear stresses of about 700 psi are computed for the plywood side panels. Working shear stress level for the design of plywood construction is on the order of only 200 psi. This stress level is used for built-up beam construction for applications in conventional architecture that involve structures such as building wall support beams where no noticeable deformation is acceptable under design loads. A safety factor of four against ultimate strength is typically used under these circumstances, hence the 700 psi shear stress calculated for the boxes is expected to be well below the ultimate strength of the plywood in shear. Since normal direction working stresses for plywood are about 1400 psi in both tension and compression, ultimate strength in shear at least equal to this would be expected; however, rather large deformations could develop before shear resistance at this stress level would develop. These numbers are consistent with the observed test results; specifically, that there is considerable deformation of the boxes under the four foot drop test, deformation that certainly would not be acceptable in a beam supporting a roof of a warehouse under normal snow loads, for example; but that the boxes do not fall apart.

The challenge with this packaging was to show that the specific 10 CFR Part 71 requirements applicable to all fissile packagings are satisfied here. The staff review of the NCT drop test results supports the conclusion that the performance of these boxes would be adequate when subjected to the four foot drop test impacts.

2.6.8 Corner Drop

The corner drop test does not apply to packages weighing more than 110 lbs. The lightest of the packages under consideration in this SARP is 220 lbs.

2.6.9 Compression

The SARP refers to testing to show that the 10 CFR 71.71(c)(9) compression test ("stacking test") requirements are met. The testing was performed by applying the specified loading as a dead weight for the specified period of time and observing that the packaging sustained no damage. Photos of each test are included in the SARP. The tests demonstrate that the packaging will not be damaged when loaded to the 10 CFR 71.71(c)(9) conditions. Staff review of this data, and the observation that the stresses remain well below 500 psi in the box sides when stacked to the required height, leads to the conclusion that the 10 CFR 71.43 requirements will be satisfied for this test condition.

2.6.10 Penetration

For the last of the NCT tests, the 10 CFR 71.71(c)(10) penetration test, the SBWSCs SARP also references physical tests documented in the "Final Evaluation Report". The damage resulting from the impact of the 13-lb steel bar dropped axially from a height of 40 inches, namely minor dents and in one case a crack in one of the boards, would not detrimentally affect the required performance of the boxes, namely the containment of the large uranium objects being shipped. The staff reviewed this information and concluded that performance of these wooden boxes would not be affected adversely by the penetration test impacts.

2.7 Hypothetical Accident Conditions (HAC)

Consideration of the 10 CFR 71.73 HAC for the SBWSC in the structural evaluation portion of the SARP is limited to the observation that the packaging is not a factor in meeting the requirements subsequent to these tests. It is noted that for the contents of these packages, the 10 CFR Part 71 requirements for Type AF Packages are met without the packaging. Specifically, the containment requirements are met because the A_2 value for this material is infinite and therefore there are no release limits. The shielding requirements are met automatically since shielding is not required for this material. Finally, the criticality requirements are shown to be met, in Chapter 6 of the SARP, without regard for any geometrical restraint of the contents, and with the "worst case" optimal moderation with water.

2.8 Special Form

This packaging is not used for shipping special form contents.

2.9 Fuel Rods

This packaging is not used for shipping fuel rods.

2.10 Appendix

The appendix to Chapter 2 of the SARP includes a list of relevant references. No additional information is required in the Chapter 2 Appendix of this SARP.

2.11 Findings

Based on a review of the SBWSC SARP and on independent confirmatory review of selected critical features of this packaging, the staff concludes that the package design has adequate structural integrity to meet the requirements of 10 CFR Part 71.

CHAPTER 3 - THERMAL

3.1 Discussion

A steady-state energy balance at the packaging surface demonstrates that the package meets the regulatory thermal requirements of 10 CFR 71.43(g) and 71.71(c) for NCT. As the amount of mass is limited to subcritical mass and the A_2 value of the payload is unlimited, a thermal evaluation for the Hypothetical Accident Condition thermal event is not necessary because the packaging is not a factor in meeting the regulatory requirements of 10 CFR 71.55(e) and 71.51(a)(2), respectively, subsequent to the HAC tests.

The heat source in the SBWSC has been confirmed by the staff using an analysis that shows that, for a maximum loading of 1633 kg (3600 lb) of 1.25 wt% ^{235}U, the total decay heat source in any package is less than 0.1 watt.

3.2 Summary of Thermal Properties of Materials

The thermal properties of materials are not required in the thermal evaluation of package temperatures during NCT because the thermal analysis described in Section 3.4.1 of this SER addresses the conservation of energy at the external surface of the packaging, thus ignoring the detailed construction of the packaging. However, the SARP has presented the thermal properties of the materials used in the wooden containers and the values listed are in agreement with the values published in the standards or handbooks.

3.3 Technical Specifications of Components

The thermal and structural protection to the uranium metal during NCT is provided by the wooden box. The process of slow degradation of wood with release of combustible gases, as described in Chapter 3 of Fire Protection Handbook by A. E. Cote, Seventeenth Edition (1991), begins at 200°C (392°F). The maximum safe working temperature for wood without leading to ignition when exposed over long periods to that temperature, as specified in page 15-2 of Wood Handbook, prepared by Forest Products Laboratory, U.S. Department of Agriculture (1987), is 100°C (212°F). The allowable temperature limit of 100°C (212°F) for the package for the NCT will assure no degradation and no ignition of wood.

3.4 Thermal Evaluation for NCT

3.4.1 Thermal Model

The staff confirmatory thermal analysis for NCT with insolation was carried out by applying the steady-state energy balance at the top flat surface of the package. The analysis considered the insolation rate of 800 g.cal/cm^{2}· specified in 10 CFR 71.71(c) for a 12-hour period, and equated the total incoming insolation heat flux on the top surface of the package to the outgoing heat flux by convection and radiation to the environment. This procedure provides a conservative prediction when the heat source in a system is very small, such as in the SBWSC where the internal heat load is less than 0.02 % of the insolation heat flux. For additional conservatism, the analysis considered the surface absorptivity value of 1.0 and ignored the internal thermal diffusion to the side surfaces where the insolation heat flux is 0.25% of that on the top surface.

3.4.2 Maximum Temperatures

For the NCT with 38°C (100°F) ambient temperature and the package in the shade, the staff analysis confirms that the package temperature will not rise more than 0.05°C (0.1°F) above the ambient since the internal heat load is less than 0.1 watt. The packaging therefore complies with the accessible surface temperature limit of 50°C (122°F) in a non-exclusive use and 82°C (180°F) in an exclusive use shipment as specified in 10 CFR 71.43(g).

For the case of NCT with insolation, the staff analyses calculated the maximum temperatures of the package to be 93°C (200°F) at the top flat surface of the packaging. The maximum temperatures of the package are well below the allowable 100°C (212°F) to assure no degradation and no ignition of wood.

3.4.3 Minimum Temperatures

The staff analysis shows that the maximum change in package temperatures due to internal heat load will be less than 0.05°C (0.1°F). Therefore, the minimum temperature of the package will be -40°C (-40°F) when exposed to an ambient temperature of -40°C (-40°F) in still air and shade, the coldest regulatory environment specified in 10 CFR 71.71 (c)(2). As discussed in Chapter 2 of this SER, the conventional hardwood/plywood/pine nailed and banded box construction is not sensitive to the hot and cold temperature conditions of 10 CFR 71.71(c)(1) and (2).

3.4.4 Maximum Internal Pressures

The pressure will not rise in the SBWSC because the package is not leaktight.

3.4.5 Maximum Thermal Stresses

The staff analysis shows that the temperature gradients are less than 14 °C/m (0.64 °F/in), during NCT and will not cause any thermal stress in the structural members of the packaging.

3.4.6 Evaluation of Package Performance for NCT

The results of the SARP and staff-confirmatory analyses show that the design of the SBWSC is adequate to meet the thermal requirements of 10 CFR Part 71 for NCT.

3.5 HAC Thermal Evaluation

The HAC thermal event analysis is not required because the packaging is not a factor in meeting the requirements of 10 CFR Part 71 in the containment, shielding, and criticality reviews as discussed in Chapters 4, 5, and 6 of this SER, respectively.

CHAPTER 4 - CONTAINMENT

The SBWSC is designed to ship unirradiated uranium billets, ingots, derbies, and scrap metal left over from the N Reactor program with enrichment of a maximum of 1.25 +/-0.006 wt% ^{235}U. The radioactive contents are limited to the contents specified in Table 1.2.3-1 of the SARP. Since the contents are unirradiated uranium products enriched to less than 5 wt% ^{235}U, the A_2 value is unlimited according to Appendix A of 10 CFR Part 71. Thus, the SBWSC is classified as a Type AF package.

The containment boundary of the SBWSC consists of the wooden structure of the container. The SBWSC are divided into two classes, a box with a lid and a pallet with a cover. The pallet with a cover is essentially an upside-down box with a pallet for a "lid". There are no penetrations into the containment boundary except for the cracks and seams between wooden pieces. Both classes of boxes are horizontally and vertically banded with 3.18 cm (1.25 in) steel bands that meet the requirements of ASTM D-3953-91 and have a minimum tensile strength of 30,025 N (6750 lb). Each band is secured with at least one seal that is closed with two pairs of notches per Figure 1 in ASTM D-3953-91. The steel bands are installed using the manufacturers guidelines and the guidelines in ASTM D-4675-93. Positive closure is provided by the steel banding. The security boundary provided during transportation is the locked and sealed trailer used exclusively to transport the containers or the steel bands on the shipping containers which must be cut to open the container. Dimensions and tare weights of the allowed SBWSC are listed in Table 1.2.1-1 of the SARP. Tables 1.2.3-1 and 1.2.3-2 of the SARP list the materials approved for shipment in the SBWSC, and the recommended packaging for each payload, respectively.

The release criteria for the containment boundary are no loss or dispersal of radioactive contents, no significant increase in external surface radiation levels, and no substantial reduction in the effectiveness of the packaging under the NCT per 10 CFR 71.43(f). The containers are not expected to survive the HAC, which is acceptable since the containers do not carry more than an A_2, i.e., the A_2 value is unlimited. The release requirements of 10 CFR 71.43(f) for the NCT have been shown in the SARP to be satisfied by testing. The conclusions presented in the structural and thermal evaluations, Chapters 2 and 3 of this SER, based upon confirmatory analyses of the packaging, demonstrate that the NCT do not reduce the effectiveness of the containment boundary of the package.

The evaluation of the containment design by the staff provides reasonable assurance that under both NCT and HAC, the specified contents can be safely transported in the SBWSC.

The staff concludes that the containment boundary of the SBWSC will not release radioactive material in excess of the regulatory limits allowed by NRC regulations and DOE Orders under both NCT and HAC and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71, 49 CFR Part 173 and DOE Order 460.1A have been met.

CHAPTER 5 - SHIELDING

The payload to be shipped in the SBWSC includes N Reactor Mark I, Mark IV, and Mark 15 inner and outer ingots, RMI billets, and FERMCO material consisting of derbies, ingots, ingot sections, and scrap. All of these materials are unirradiated, slightly enriched uranium containing 0.95-1.25 wt.% U-235, trace amount of U-234 and U-236, and a balance of U-238.

The shielding evaluation of the SBWSC in the SARP involved specification of the radiation source terms and the payload configuration. The ORIGEN-2 code was used in the calculation of the photon and neutron source terms for the three uranium isotopic compositions listed in Table 5.2 of the SARP. For each uranium isotopic composition, the maximum source strengths per gram of material were calculated as a function of radiation energy at a decay time of one year. The source terms for the individual pieces of ingots, billets, derbies, and scrap were obtained by multiplying the source strengths per gram with the mass of the individual pieces calculated from their geometrical volumes and the density of uranium (18.96 g/cc). The geometrical volumes of the pieces were calculated from the physical dimensions, which are listed in Table 1.2.3-1 of the SARP along with the approximate weight of the payload pieces.

For the payload configuration, the SARP assumed that no radiation shielding is provided by the SBWSC under both NCT and HAC. Dose rates were calculated for each piece at the surface and at 1 m, 2 m, and 6 m from both the end and the side using the MCNP code with the photon and neutron source terms determined from the ORIGEN-2 calculations. The total dose rates for the various content types were calculated by one of two methods: (1) multiplying the dose rates calculated for a single piece by the maximum number of pieces allowed in a shipment; or (2) calculating the dose rates at specified distances from a square array containing the maximum number of pieces. The maximum number of pieces allowed for each shipment was determined by the total weight of the payload, which has a limit of 40,000 lb. (18,144 kg). The first method is ultra-conservative because it is physically impossible to stack multiple payload pieces at the location of a single payload piece. Therefore, the resulting dose rate should give the absolute maximum dose rate for any configuration containing such number of payload pieces. The second method is also conservative, and was used only when the dose rates obtained by the first ultra-conservative method exceed the regulatory limits. Skin dose rates from beta particles were included in the evaluation of each payload only for HAC, but not for NCT because of the limited range of beta particles which would be easily stopped by the SBWSC.

The staff has examined the ORIGEN-2 and MCNP input files and found the models acceptable for use in the shielding evaluation of SBWSC. Among the various types of payloads, the worst-case results were obtained for 64 Mark 15 ingots. The total dose rates calculated by the ultra-conservative method at the surface, 1 m, 2 m, and 6 m from the surface are 1.67, 0.015, 0.004, and 4.3e-4 mSv/h (or 167, 1.5, 0.39, and 4.3e-2 mR/h), respectively. All of these calculated dose rates are much smaller than the regulatory limits permitted for an exclusive use shipment: 10 mSv/h (1,000 mR/h) on the external surface of the package; 10 mSv/h (1,000 mR/h) at 1 m from the external surface of the package under HAC; 2 mSv/h (200 mR/h) at any point on the outer surface of the vehicle; 0.1 mSv/h (10 mR/h) at 2 m from the outer lateral surfaces of the vehicle; and 0.02 mSv/h (2 mR/h) in any normally occupied space in the vehicle.

There is no change of the shielding evaluation in the Rev. G SARP, even though the maximum payload weight limit based on shielding has been increased from 40,000 lb to 42,000 lb. This amounts to a 5% increase in the total payload weight and a proportional increase in external radiation levels. However, due to the ultra conservative nature of the shielding analysis, a 5% increase in radiation levels are still much less than the allowable regulatory limits.

In summary, the staff confirmatory shielding evaluation finds the SBWSC in compliance with the 10 CFR Part 71 dose rate limits for NCT and HAC. Pre-shipment radiological survey of the containers with payload will ensure that the regulatory dose rate requirements are satisfied for radiation safety. The Transport Index for radiation, based on the calculated worst-case dose rate at 1 m from the external surface of the payload, is 1.5. However, because of the ultra-conservative nature of the shielding evaluation, the dose rate measured during the radiation survey of the package after loading is expected to be far lower than 1.5 mR/h at 1 m.

CHAPTER 6 - CRITICALITY

The criticality confirmatory evaluation in this SER addresses the following five groups of payloads described in Tables 1.2.3-1 and 1.2.3-2 of the Rev. G SARP:

1. N Reactor Ingots – Mark I Outer, Mark I Inner, Mark IV Outer, and Mark IV Inner;

2. RMI Forged Billets (16-in. L only) – Mark I Outer, Mark I Inner, Mark IV Outer, and Mark IV Inner;

3. Mark 15 Inner Ingots;

4. FERMCO Derby Ingots; and

5. FERMCO Primary Ingots – 12-in. OD x 17-in. L ingots, 12-in. OD x 26-in. L ingots, 13-in. OD x 30-in. L ingots, 9-in. OD x 30- in. L ingots.

The N Reactor Ingots, RMI Forged Billets, and Mark 15 Inner Ingots were the initial contents authorized as contents in Revision 9 of the CoC. The FERMCO Derbies were added to the authorized contents in Revision 10 of the CoC. The FERMCO Primary Ingots, the revised loading of the RMI Forged Billets, and the revised Transport Index for the Mark 15 Inner Ingots are added with Revision 11 of the CoC.

The staff reviewed the criticality analyses presented in the SARP and confirmed by independent analyses that each payload listed above meets the criticality safety requirements of 10 CFR Part 71 under NCT and HAC.

The payloads that are not covered in this SER include Mark 15 Outer Ingots, FERMCO Product Ingots, FERMCO Ingot Sections, and FERMCO Scrap listed in Table 1.2.3-2 of the Rev. G SARP.

6.1 Criticality Safety Evaluation

There is no special feature incorporated in the design of the SBWSC for criticality control. The containers are not tested under HAC and therefore cannot be credited to maintain package integrity under all conditions of transport. For criticality safety evaluation, the applicant conservatively assumed that all SBWSCs in a shipment are burned during the hypothetical accident and the ingots are "scattered and arranged" in the most reactive configuration as required by 10 CFR 71.55 and 10 CFR 71.59. Consequently, the most limiting criticality safety configuration is determined by the 2xN damaged array analysis where N is the number of packages in the array. (Exceptions are the N Reactor Ingots which are limited by the 42,000 lb maximum content weight in a shipment, which is based on shielding consideration, not criticality.) For the other payloads that require a 2xN damaged array analysis, close and full water reflection (12 in.) is assumed on all sides of the array in the Monte Carlo MCNP calculations.

The size of the array (N) is determined when the adjusted effective neutron multiplication factor (k-adj) for the 2xN damaged array meets the subcriticality criterion of k-adj $\leq$ 0.95, i.e.,

$$\text{k-adj} = \text{k-eff} + 0.00258 + 2 \times (0.006^2 + \sigma^2)^{0.5} \leq 0.95$$

where k-eff and σ, the standard deviation, are obtained in the MCNP calculations; the other constants are the code bias (0.00258) and uncertainty (0.006) obtained in benchmark calculations against critical experiments. The formula used in computing k-adj is consistent with that recommended in NUREG/CR-5661, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," April 1997.

6.2 Transport Index and Subcriticality for Maximum Payload

As mentioned before, the maximum payloads for the N Reactor Ingots are determined by the content weight limit of 42,000 lb in a shipment. Based on this weight limit and the weight of the ingots, the applicant calculated the number of packages allowed in an exclusive use shipment. As Table 1.2.3-2 in Rev. G SARP shows, the applicant requested that up to 13 packages be allowed for each type of the N Reactor Ingots (Mark I Outer, Mark I Inner, Mark IV Outer, and Mark IV Inner) in an exclusive use shipment. The transport index (TI) for the N Reactor Ingots can thus be calculated from TI = 100/13 = 7.6 after round off. The TI values for the N Reactor Ingots are listed in Table 1 of this SER, along with the k-adj values obtained in the staff confirmatory evaluation. The k-adj values for the N Reactor Ingots are all below the subcriticality criterion of 0.95 with considerable safety margin.

For the other types of payloads addressed in this SER and listed in Table 1, the applicant used two methods to determine the maximum payload either by performing a 2xN damaged array analysis, or by using "maximum mass" values that were established from other similar finite arrays which have been proven criticality-safe.

In the 2xN damaged array analysis for a payload such as the RMI Forged Billets, Mark 15 Ingots, or FERMCO Derby Ingots, the applicant first conducted a systematic search to determine the optimal lattice parameters for the axial moderator gap, moderator density, and lattice pitch. The applicant then re-optimized the finite array to obtain the minimum leakage surface by enclosing the array in an idealized spherical geometry. The staff has performed independent calculations and confirmed that the optimal lattice parameters and the most reactive configurations have indeed been established in the SARP for the RMI Forged Billets, the Mark 15 Inner Ingots, and the FERMCO derbies.

The "maximum mass" method was used in the SARP to determine the number of packages allowed in a shipment for the FERMCO Primary Ingots. Knowing the following mass values for arrays of shorter ingots that have been demonstrated to be criticality safe,

1. 8,430 kg for array of FERMCO Derby Ingots of 12-in. OD x 5-in. L

2. 12,144 kg for array of FERMCO Ingot Sections of 13-in. OD x 6-in. L

3. 13,067 kg for array of FERMCO Primary Ingots of 9-in. OD x 15-in. L

the applicant determined the allowable number of FERMCO primary ingots of the same diameters (OD) but longer length by dividing the above "maximum masses" by the weight of each type of FERMCO primary ingots. The resulting number of ingots then determine the number of package (N) per shipment based on the number of ingots per package. By definition, the transport index (TI) for criticality control is TI = 50/N, and the sum of TI of all packages must not exceed 100 for an exclusive use shipment.

The staff has confirmed the minimum TI values listed in the SARP for payloads that were determined either by finite array analysis (RMI Forged Billets, Mark 15 Ingots, or FERMCO Derby Ingots) or by the "maximum mass" method (FERMCO Primary Ingots). All of the staff confirmatory calculations were performed for finite arrays of the allowable number of ingots with optimal lattice parameters in the most reactive configuration. The resulting k-adj values for the criticality-limited payloads are listed in the following table. Notice that while all k-adj values are less than the subcriticality criterion of 0.95, the margins of safety are considerably greater for the FERMCO primary ingots due to the conservative nature of the maximum mass method.

Minimum TI and k-adj values obtained in confirmatory evaluation for selected payloads in the SARP (Rev. G)

Group	Description	SBWSC Model	Ingots per Package	Minimum TI	Confirmatory Analysis k-adj**
N Reactor Ingots	Mark I Outer	G-4273-6	2	7.6*	0.93934
	Mark I Inner	G-4273-6	2	7.6*	0.85616
	Mark IV Outer	G-4273-6	2	7.6*	0.85831
	Mark IV Inner	G-4273-6	2	7.6*	0.85320
RMI Forged Billets	Mark I Outer	G-4255	3	16.4	0.94110
	Mark I Inner	G-4255	5	4.8	0.94163
	Mark IV Outer	G-4255	3	4.5	0.93471
	Mark IV Inner	G-4255	5	5.0	0.93870
Mark 15 Ingots	Mark 15 Inner Ingots	G-4273-5	4	10.2	0.93154
FERMCO Derby	FERMCO Derby Ingots	G-4214 or G-4292	2	4.1	0.94178
FERMCO Primary Ingots	12"D x 17"L	G-4273-6	2	14.0	0.88012
	12"D x 26"L	G-4273-6	1	21.4	0.84833
	13"D x 30"L	G-4273-6	1	10.1	0.85510
	9"D x 30"L	G-4273-5	2	9.0	0.86114

*TI based on weight limit of 42,000 lb in an exclusive use shipment.

**k-adj values obtained in MCNP confirmatory calculations for 2xN damaged array of ingots determined by the corresponding minimum TI in the table.

6.3 Summary

The staff has evaluated the criticality safety analysis presented in the SARP (Rev. G). The staff has independently verified that the minimum TIs (and the corresponding maximum number of packages) for the payloads listed in the SARP and Table 1 of this SER are conservative and meet the 10 CFR Part 71 requirements under NCT and HAC. All payloads addressed in this SER can thus be safely packaged and transported in the designated models of the SBWSC.

CHAPTER 7 - OPERATING PROCEDURES

The operating procedure requirements presented in Chapter 7 of the SARP for the SBWSC provide specific guidance for:

1. loading, closure, and preshipment checks,

2. receiving checkout, opening, unloading, and

3. empty packaging preparations.

Each container must first be inspected and discrepancies corrected before being used. The inspection and repair criteria are put forth in Section 8.2 of the SARP.

Radiation surveys are prescribed at two stages of the loading process. The first ensures that the empty packaging was not contaminated during storage to protect the loading and handling personnel and the second ensures compliance with shipping regulations.

Assembly verification leakage testing is not required as part of the operating procedures described in Chapter 7 of the SARP.

The staff concludes that the operating procedure requirements presented in the SARP are acceptable and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71, 49 CFR Part 173, DOE Order 460.1A, and DOE Order 460.2 have been met.

CHAPTER 8 - ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The requirements for acceptance tests to be performed on each SBWSC prior to first use are presented in Section 8.1 of the SARP. These tests include only visual inspections. Structural, pressure, and leakage testing are not required.

The maintenance program used to ensure continued performance of the packaging is described in Section 8.2 of the SARP. This program includes:

1. structural and pressure tests,

2. leakage rate tests, and

3. subsystem maintenance.

The packagings do not require leakage rate tests because the allowed release rate discussed in Chapter 4 of this SER is unlimited.

The maintenance program also includes guidance on the repair of components. Periodic testing is not required, and there are no components that need regular replacement.

The staff concludes that the acceptance tests and maintenance program requirements presented in Chapter 8 of the SARP are acceptable and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71, 49 CFR Part 173 and DOE Order 460.1A have been met.

CHAPTER 9 - QUALITY ASSURANCE

The requirements for a Quality Assurance (QA) Plan presented in the QA Chapter of the SARP have been reviewed and found to meet the QA requirements of 10 CFR Part 71, Subpart H. These QA requirements provide sufficient control over all items and quality-affecting activities that are important-to-safety as applied to the design, fabrication, assembly, inspection, testing, operation, maintenance, and repair of the SBWSC. The QA requirements are based on a graded approach as described in 10 CFR 71.101. The graded approach in the QA Chapter includes an important-to-safety Q-list for each item and is graded based on the design function of the item relative to the safety and performance requirements for the complete shipping package. The quality assurance levels for each component are listed in Table 9.3.2-1 of the SARP. The Q-list uses three QA levels with associated definitions for each. The QA level of each important-to-safety item is based on specific criteria. The QA requirements assure that the SBWSC is designed, fabricated, and tested in accordance with the drawings identified in the SARP. In addition, the QA Chapter requires the user to invoke the same level of QA requirements for the use, maintenance, and repair of the packaging as is required for the procurement, fabrication, and acceptance testing of the original packaging. The QA levels for important-to-safety items and activities are based on the following definitions:

1. <u>Category A (Critical)</u>

   Category A items are structures, components, and systems whose failure or malfunction could directly result in an unacceptable condition of shielding or an unsafe geometry compromising criticality control that adversely affects public health and safety.

2. <u>Category B (Major)</u>

   Category B items are structures, components, and systems whose failure or malfunction could indirectly result in an unacceptable condition of shielding or an unsafe geometry compromising criticality control that adversely affects public health and safety. An unsafe condition of shielding or an unsafe geometry comprising criticality control could result only if the failure or malfunction of a Category B item occurred in conjunction with the failure or malfunction of other items in the same QA category.

3. Category C (Minor)

Category C items are structures, components, and systems whose failure or malfunction would not reduce packaging effectiveness and would not result in an unacceptable condition of shielding or an unsafe geometry compromising criticality control that adversely affects public health and safety regardless of other failures or malfunctions of items in the same QA category.

After determining the applicable QA category, the appropriate level of QA effort for design, procurement, fabrication, testing, operations, maintenance, modification, and repair activities is determined from the 18 QA elements identified in 10 CFR Part 71, Subpart H. The 18 elements identified in the SARP are organization; quality assurance program; design control; procurement document control; instructions, procedures, and drawings; document control; control of purchased material, equipment, and services; identification and control of material, parts, and components; control of special processes; inspection control; test control; control of measuring and test equipment; handling, shipping, and storage control; inspection, test, and operating status; control of nonconforming materials, parts, or components; corrective action; QA records; and QA audits.

The QA Chapter of the SARP includes independent verification of operational activities and inspection points considered to be critical in satisfying the regulatory requirements for shielding and criticality control as identified in 10 CFR Part 71. Verification of critical activities is contained in Section 9.3.10 of the SARP.

The staff concludes that the QA requirements presented in the QA Chapter of the SARP are in conformance with the established criteria in Subpart H of 10 CFR Part 71, 49 CFR Part 173, and DOE Order 460.1A.

Approved:

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